CLAIMS

We claim:

1. A surface inspection apparatus including, in combination:

an illumination source for directing a light beam onto a workpiece to generate scattered light that includes light scattered from defects of the workpiece and light scattered in accordance with the ordinary scattering pattern of the workpiece;

a light detection element capable of receiving light and capturing a two-dimensional image of the light and translating the two-dimensional image into an electrical signal;

a programmable light selection array for receiving light scattered from the workpiece and selectively directing the light scattered from defects of the workpiece onto the photosensor; and

processing circuitry for receiving an electrical signal from the light detection element and using it to conduct surface analysis of the workpiece;

the combination comprising a means for detecting defects of the workpiece.

2. The apparatus of Claim 1 wherein the programmable light selection array comprises an array of reflector elements that are selectively activated to *direct* the light scattered from defects of the workpiece onto the light detection element.

3. The apparatus of Claim 1 wherein the programmable light selection array comprises an array of filter elements that are selectively activated to *direct* the light scattered from defects of the workpiece onto the light detection element and substantially inhibit the ordinary scattering pattern of the workpiece from reaching the light detection element.

4. A surface inspection apparatus comprising:

an illumination source for directing a light beam onto a workpiece to generate scattered light that includes light scattered from defects of the workpiece and light scattered in accordance with the ordinary scattering pattern of the workpiece;

a programmable light selection array positioned to receive light scattered from the workpiece and selectively direct the light scattered from defects of the workpiece onto a light detection element;

the light detection element is positioned to receive the light from the programmable light selection array and capable of translating the light into an associated electrical signal; and

processing circuitry for receiving the electrical signal and using it to conduct surface analysis of the workpiece.

5. The apparatus of Claim 4 wherein the processing circuitry for receiving the electrical signal is used to identify and categorize defects of the workpiece.

6. The apparatus of Claim 4 wherein the apparatus comprises a darkfield inspection tool.

7. The tool of Claim 4 wherein the workpiece comprises an un-patterned surface.

8. The tool of Claim 4 wherein the programmable light selection array comprises an array of reflector elements that are selectively enabled to *direct* selected portions of the light scattered from the workpiece onto the light detection element.

9. The tool of Claim 4 wherein the programmable light selection array comprises an array of filter elements that are selectively actuated to enable the selected portions of the light scattered from the workpiece to pass through the array of filter elements thereby directing said selected portions of the light onto to the light detection element.

10. The tool of Claim 4 wherein the light detection element comprises at least two photo-sensitive detector elements.

11. A surface inspection apparatus comprising:

an illumination source for directing a light beam onto a workpiece to generate

scattered light that includes light scattered from defects of the workpiece and light scattered in accordance with the ordinary scattering pattern of the workpiece;

a programmable light selection array positioned to receive light scattered from the workpiece and direct the light onto a first photodetector array;

the first photodetector array is positioned to receive the light from the programmable light selection array and capable of translating the light into an associated electrical signal;

circuitry for receiving the associated electrical signal and determining which portion of the light scattered from the workpiece comprises the ordinary scattering pattern of the workpiece;

the programmable light selection array further selectively *directs* the light scattered from defects of the workpiece onto a photosensor where it is translated into an associated defect signal; and

processing circuitry for receiving the defect signal and using it to conduct surface analysis of the workpiece.

12. The tool of Claim 11 wherein the programmable light selection array comprises an array of reflector elements that are selectively enabled to *direct* the light scattered from the workpiece onto the photosensor.

13. The tool of Claim 12 wherein array of reflector elements comprises an array of MEMS reflector elements.

14. The tool of Claim 12 wherein selected reflector elements of the array of reflector elements are actuated so that light scattered from the defects in the workpiece is selectively directed onto the photosensor and so that the light scattered by the non-defect containing portions of the workpiece is not directed onto the photosensor.

15. The tool of Claim 11 wherein the first photodetector array comprises at least two photodetector arrays and wherein the photosensor comprises at least two

photosensors.

16. The tool of Claim 11 wherein the workpiece comprises an un-patterned surface.

17. The tool of Claim 16 wherein the un-patterned surface comprises a semiconductor wafer.

18. The tool of Claim 16 wherein the un-patterned surface comprises a semiconductor wafer having at least one un-patterned layer of material formed thereon.

19. The tool of Claim 16 wherein the workpiece comprises a semiconductor wafer having a surface formed by an epitaxial fabrication processes.

20. The tool of Claim 16 wherein the workpiece comprises a semiconductor wafer formed using silicon germanium material.

21. The apparatus of Claim 11 wherein the apparatus comprises a darkfield inspection tool.

22. The apparatus of Clam 11 wherein the photosensor comprises a discrete photosensor element.

23. The apparatus of Clam 22 wherein the photosensor comprises a plurality of discrete photosensor elements.

24. The tool of Claim 22 wherein the programmable light selection array comprises an array of reflector elements that are selectively enabled to *direct* the light scattered from the workpiece onto the photosensor.

25. The tool of Claim 24 wherein array of reflector elements comprises an array of MEMS reflector elements.

26. The tool of Claim 24 wherein selected reflector elements of the array of reflector elements are actuated so that light scattered from the defects in the workpiece is selectively directed onto the photosensor and so that the light scattered by the non-defect containing portions of the workpiece is not directed onto the photosensor.

27. The apparatus of Claim 11 wherein the photosensor comprises a second photodetector array.

28. The tool of Claim 27 wherein the programmable light selection array comprises an array of reflector elements that are selectively enabled to *direct* the light scattered from the workpiece onto the photosensor.

29. The tool of Claim 28 wherein array of reflector elements comprises an array of MEMS reflector elements.

30. The tool of Claim 28 wherein selected reflector elements of the array of reflector elements are actuated so that light scattered from the defects in the workpiece is selectively directed onto the photosensor and so that the light scattered by the non-defect containing portions of the workpiece is not directed onto the photosensor.

31. The apparatus of Clam 11 wherein the first photodetector array also operates as the photosensor.

32. The tool of Claim 11 wherein the programmable light selection array comprises an array of reflector elements that are selectively enabled to *direct* the light scattered from the workpiece onto the photosensor.

33. The tool of Claim 32 wherein array of reflector elements comprises an array of MEMS reflector elements.

34. The tool of Claim 32 wherein selected reflector elements of the array of reflector elements are actuated so that light scattered from the defects in the workpiece is selectively directed onto the photosensor and so that the light scattered by the non-defect containing portions of the workpiece is not directed onto the photosensor.

35. The tool of Claim 31 wherein the programmable light selection array comprises an array of filter elements that are selectively activated and deactivated to enable the light scattered from the workpiece to pass through the array of filter elements thereby directing the light scattered from the defects of the workpiece onto the photosensor.

36. The tool of Claim 35 wherein array of filter elements comprises an array of LCD filter elements.

37. The tool of Claim 35 wherein array of filter elements comprises an array of selectively activatable polarizer elements that can filter by polarization.

38. An surface inspection apparatus comprising:

an illumination source for directing a light beam onto a workpiece;

a programmable light selection array positioned to receive light scattered from the workpiece, the programmable light selection array for directing said light onto to a photodetector element and also capable of selectively directing selected portions of the light onto to a photosensor element;

the photodetector element being positioned such that it receives light from the programmable light selection array and translates said received light into an associated electrical signal;

processing circuitry for receiving and analyzing the associated electrical signal from the first photodetector element and thereby determining an ordinary scattering portion of the of the light scattered from the workpiece that is associated with an ordinary scattering pattern of the workpiece and determining a defect portion of the light scattered from the workpiece that is associated with defects of the workpiece;

control circuitry for activating and deactivating light selection elements of the programmable light selection array so that said selected portions of the light comprising the defect portion of the light scattered from the workpiece are selectively directed onto the photosensor element that translates said defect portion into a defect electrical signal;

defect analysis circuitry for receiving and analyzing the defect electrical signal from the photosensor element to characterize defects the workpiece.

39. The tool of Claim 38 wherein the workpiece comprises an un-patterned surface.

40. The tool of Claim 39 wherein the un-patterned surface comprises a semiconductor wafer.

41. The tool of Claim 39 wherein the un-patterned surface comprises a semiconductor wafer having at least one un-patterned layer of material formed thereon.

42. The tool of Claim 39 wherein the workpiece comprises a semiconductor wafer having a surface formed by epitaxial fabrication processes.

43. The tool of Claim 39 wherein the workpiece comprises a semiconductor wafer formed using silicon germanium material.

44. The apparatus of Claim 38 wherein the photodetector element operates as the photosensor element.

45. The apparatus of Claim 44 wherein the programmable light selection array comprises a filter array comprising a plurality of filter elements; and

wherein the control circuitry selectively activates and deactivates the filter elements such that the defect portion of the light is selectively directed onto the photosensor element and such that the ordinary scattering portion of the light is substantially blocked from the photosensor element.

46. The apparatus of Claim 44 wherein the programmable light selection array comprises a reflector array comprising a plurality of reflector elements; and

wherein the control circuitry selectively actuates the reflector elements so that the defect portion of the light is selectively reflected onto the photosensor element and so that ordinary scattering portion of the light scattered from the workpiece is selectively reflected away from the photosensor element such that substantially all of the ordinary scattering portion of the light is not detected by the photosensor element.

47. The apparatus of Claim 38 wherein the photodetector element and the photosensor element are each comprised of different detector elements.

48. The apparatus of Claim 47 wherein the photodetector element comprises a photodetector array comprising a plurality of photo-sensitive detector elements and wherein the photosensor element comprises a single discrete photo-sensitive detector device.

49. The apparatus of Claim 48 wherein the single discrete photo-sensitive detector device that comprises the photosensor elements is selected from among the group of devices consisting of a photo-multiplier tube, a photodiode, and avalanche photodiode.

50. The apparatus of Claim 48 wherein the programmable light selection array comprises a reflector array comprising a plurality of reflector elements; and

wherein the control circuitry selectively actuates the reflector elements to selectively direct the defect portion of the light scattered from the workpiece onto the photosensor element.

51. The apparatus of Claim 50 wherein the wherein the control circuitry selectively actuates the reflector elements to selectively direct the ordinary scattering pattern of the light scattered from the workpiece onto the photodetector array.

52. The apparatus of Claim 38 wherein the processing circuitry, the control circuitry, and the defect analysis circuitry are incorporated into a single electronic circuit element.

53. A method for conducting surface inspection comprising:

providing a workpiece for inspection;

illuminating the workpiece to produce scattered light that includes light scattered from defects in the workpiece causing defect scatter and includes light scattered from non-defect portions of the workpiece generating an ordinary scattering pattern of the workpiece;

selectively detecting the defect scatter; and

analyzing the selectively detected defect scatter to characterize the workpiece surface.

54. The method of Claim 53 wherein selectively detecting the defect scatter comprises:

detecting the scattered light;

determining which of the scattered light comprises the ordinary scattering pattern of the workpiece; and

after identifying the ordinary scattering pattern, selectively excluding the ordinary scattering pattern from detection, thereby selectively detecting the defect scatter.

55. The method of Claim 54 wherein analyzing the selectively detected defect scatter includes analyzing the defect scatter to characterize defects of the workpiece surface.

56. The method of Claim 54 wherein

detecting the scattered light comprises detecting the scattered light such that two dimensional images of the scattered light are generated;

wherein determining which of the scattered light comprises the ordinary scattering pattern comprises analyzing the two-dimensional images to determine a spatial light distribution that corresponds to the ordinary scattering pattern of the workpiece; and

wherein selectively detecting the defect scatter comprises selectively detecting scattered light that does not form part of the ordinary scattering pattern of the workpiece.

57. The method of Claim 56 wherein determining which of the scattered light comprises the ordinary scattering pattern comprises analyzing the two-dimensional images to determine a spatial light distribution that corresponds to the majority of the light and defining this distribution as the ordinary scattering pattern of the workpiece.

58. The method of Claim 57 wherein the spatial light distribution that corresponds to the majority of the light is defined as a spatial light distribution pattern that contains at least about 80% of the detected scattered light.

59. The method of Claim 57 wherein the spatial light distribution that corresponds to the majority of the light is defined as a spatial light distribution pattern that contains at about 99% of the detected scattered light.

60. The method of Claim 57 wherein selectively detecting the defect scatter comprises selectively detecting scattered light such that an optimal signal-to-noise ratio is achieved for defect detection.

61. The method of Claim 56 wherein selectively detecting the defect scatter is accomplished by selectively reflecting the light comprising the ordinary scattering pattern away from detectors used to detect the defect scatter such that the detectors detect defect scatter and do not detect substantially all of light of the ordinary scattering pattern.

62. The method of Claim 61 wherein selectively reflecting the light comprising the ordinary scattering pattern away from detectors is accomplished by selectively actuating individual reflectors of a reflector array to reflect the light that comprises the ordinary scattering pattern away from detectors used to detect the defect scatter.

63. The method of Claim 56 wherein selectively detecting the defect scatter is accomplished by selectively filtering the scattered light so that substantially all of light comprising the ordinary scattering pattern is prevented from reaching detectors used to detect the defect scatter.

64. The method of Claim 63 wherein selectively filtering the scattered light comprising comprises selectively activating individual filter elements of an LED filter array thereby passing the light corresponding to the defect scatter and filtering the light comprising the ordinary scattering pattern such that substantially all of the light comprising the ordinary scattering pattern fails to reach the detector.